



Fact Sheet

High-voltage direct current transmission (HVDC)

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Technology:

- A high-voltage direct current (HVDC) transmission link consists primarily of a **converter station**, in which the AC voltage of the conventional power grid is converted into DC voltage, a **power transmission line**, and another **converter station** on the other end, where the voltage is converted back into AC.
- The electricity can be transported in **both directions**. The lines can go **across land** as overhead or underground lines, or be installed **in water** as submarine cables. Also a combined installation, e.g. cable and overhead line or submarine and underground line is possible.
- Transmission losses are lower than for AC voltage. DC voltage amounts to several hundred thousand volts. The higher the voltage, the lower the transmission losses are, and the more electricity can be transmitted via the line.
- Siemens commissioned the **first HVDC transmission link rated at 800,000 volts** in China at the end of 2009, thereby establishing itself as a technology leader. Siemens will also install the **first submarine HVDC cable with a voltage rating of 600,000 volts** to connect Scotland and England.



- Generally, an HVDC transmission link has **two poles** (and also two lines between them) over which half of the electricity is transmitted. If one pole or line were to fail, half of the remaining power would still be available. Usually the connections are designed for a temporally limited overload operation.
- Besides conventional HVDC transmission technology, there is also the space-saving variant HVDC Plus, which is used especially on offshore platforms. In addition, HVDC Plus is the HVDC solution for built-up urban environments as can be encountered in San Francisco, for example.

Advantages:

- HVDC transmission has typically **30-50% less transmission losses** than comparable alternating current overhead lines. (For comparison: given 2500 MW transmitted power on 800 km of overhead line, the loss with a conventional 400-kv AC line is 9.4%; with HVDC transmission at 500 kV, it is only 6%, and at 800 kV HVDC it is just 2.6%.)
- Generally, given the same width of the cable run, **30-40% more energy transmission** is possible than with conventional overhead lines carrying alternating current.
- As a “firewall,” HVDC can **prevent** the transmission of **faults** between connected AC grids and hence prevent from blackouts.
- For lengths of about **600 km or more**, **overhead lines** using HVDC transmission technology are **more cost-effective** than AC technology.
- **Cable links longer than approximately 80 km usually require HVDC transmission.** That’s because for underground or submarine cables, hardly any electricity is delivered when AC lines are 80 km or longer (The cable capacities absorb the usable electricity). For an HVDC transmission link using submarine cable, such as the one planned between Scotland and England at 600 kV and 2,200 MW, there will be an energy loss of less than 3% in total (including cable and converter losses).



Market:

- The power transmission **market** is basically **volatile**, since it is influenced by large-scale projects.
- **The global power transmission solutions market (HVDC transmission, offshore grid connections and FACTS systems for grid stabilization) will amount to €5-7 billion per year in the next five years.**
- **The HVDC transmission market, which is included in this figure, is expected to double within the next five years from a current €2.5 billion per year.**
- The demand for HVDC transmission is increasing rapidly. In the last 40 years, HVDC transmission links with a total capacity of **100 gigawatts** (equivalent to the capacity of 100 large power plants) were installed. Another **250 gigawatts** will be added in this decade alone!
- **Siemens** as one of the biggest suppliers in the HVDC transmission sector has completed about **50 HVDC transmission projects** worldwide, one quarter of which were in China. Through these Siemens-built HVDC transmission links flows an amount of electricity sufficient to meet the average power demand of entire countries, such as Spain or Italy.

Drivers:

- **Connecting offshore wind farms to the grid:** cable lengths of approximately 80 km and more usually require HVDC transmission technology.
 - **Germany: Wind farm projects** are far offshore – due to landscape protection and higher wind yield (160 km of sea cable for Sylwin/Dan Tysk for example).
 - **Great Britain: Future wind farms** are far offshore due to the higher yield and because the near-coastal regions were already contracted out in rounds 1 and 2. For round 3 with 32 GW of wind power, areas have been identified for wind farms that are between 40 and 200 km off the coast.
- **Trans-national grid connections:** This creates integrated grids that can compensate for regional fluctuations in the production or consumption of electricity. For example: Western Link (England-Scotland), Inelfe (France-Spain) and BritNed (UK-Netherlands)



- **Power supply for areas** in which **no new power plant** is to be built (often via lines running through water). Examples: Mallorca and San Francisco
- **Back-to-back links**, which connect two AC grids and serve as a “firewall” to prevent faults from passing into the neighboring grid (e.g., Georgia - Turkey, New York - New Jersey)
- **China, India, and Brazil in particular are boom countries**, because their energy demand is growing rapidly and large distances must be bridged to ensure a supply of electricity from renewables projects.

Quotes by Tim Dawidowsky, CEO Business Unit Transmission Solutions, Power Transmission Division, Siemens Energy Sector:

- “HVDC is essential for offshore projects located far out at sea. HVDC technology is therefore a vital pillar for the energy transition.”
- “Germany will not be able to achieve its goals of expanding renewable power without a north to south power highway. Over long distances HVDC technology is the more economical option.”
- “Orders for HVDC lines with a total capacity of 250 gigawatts (GW) are anticipated for this decade. This is an enormous boom when you consider that a total of only 100 gigawatts was installed over the last 40 years.”
- “There is a great deal of interest in HVDC technology from Siemens.”
- “HVDC is also ideal for use in power generation when a power plant is not wanted, or would not be profitable or for which there is no suitable space – such as on Mallorca or in San Francisco.”
- “Our HVDC link between France and Spain can be seen as a type of model. These solutions can be used to gradually eliminate the bottlenecks in the transmission networks throughout Europe.”